**Nanoconfined water in terahertz nano-trenches**

Gangseon Ji1, Hyosim Yang1, Min Choi2, Seondo Park3, Hyeonjun An1, Hyoung-Taek Lee1, Joonwoo Jeong1, Yun Daniel Park3, Kyungwan Kim4, Noejung Park1, Jeeyoon Jeong5, Dai-Sik Kim1,3, and Hyeong-Ryeol Park1,\*

1. Department of Physics, Ulsan National Institute of Science and Technology, Ulsan 44919, Republic of Korea

2. Department of Chemistry, Ulsan National Institute of Science and Technology, Ulsan 44919, Republic of Korea

3. Department of Physics and Astronomy, Seoul National University, Seoul 08826, Republic of Korea

4. Department of Physics, Chungbuk National University, Chungbuk 28644, Republic of Korea

5. Department of Physics and Institute for Quantum Convergence Technology, Kangwon National University, Gangwon 24341, Republic of Korea

Corresponding author\* nano@unist.ac.kr

We report that the suppressed vibrational modes in nanoconfined water lead to an apparent solid-like behavior at terahertz frequencies, as observed experimentally. Terahertz nano-trenches composed of two gold films are realized using atomic layer lithography and a dilution method, with widths controlled to range from 2 to 20 nm. One reason for the anomalously low dielectric constant of thin water films is believed to be the interfacial water layers with a thickness of 0.8 nm (4 water layers). However, we found that the remaining water layers in the nano-trenches also contribute to the reduction of the dielectric constant at terahertz frequencies. Using a vibrational density of states (VDOS) model, the vibrational degrees of freedom of water molecules align with experimental results, featuring a number of vibrational modes (P) proportional to the nanoconfined volume (P~V). Through low-temperature measurements, we observed the absence of phase transition in 1.5 nm nano-trenches, which consist solely of interfacial water layers. Phase transitions in water emerged with increasing gap width, and at 20 nm, the behavior closely resembled that of bulk water.